

# **A System Approach to Machinery Condition Monitoring and Diagnostic**

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# **Machinery Diagnostics and Condition Assessment**

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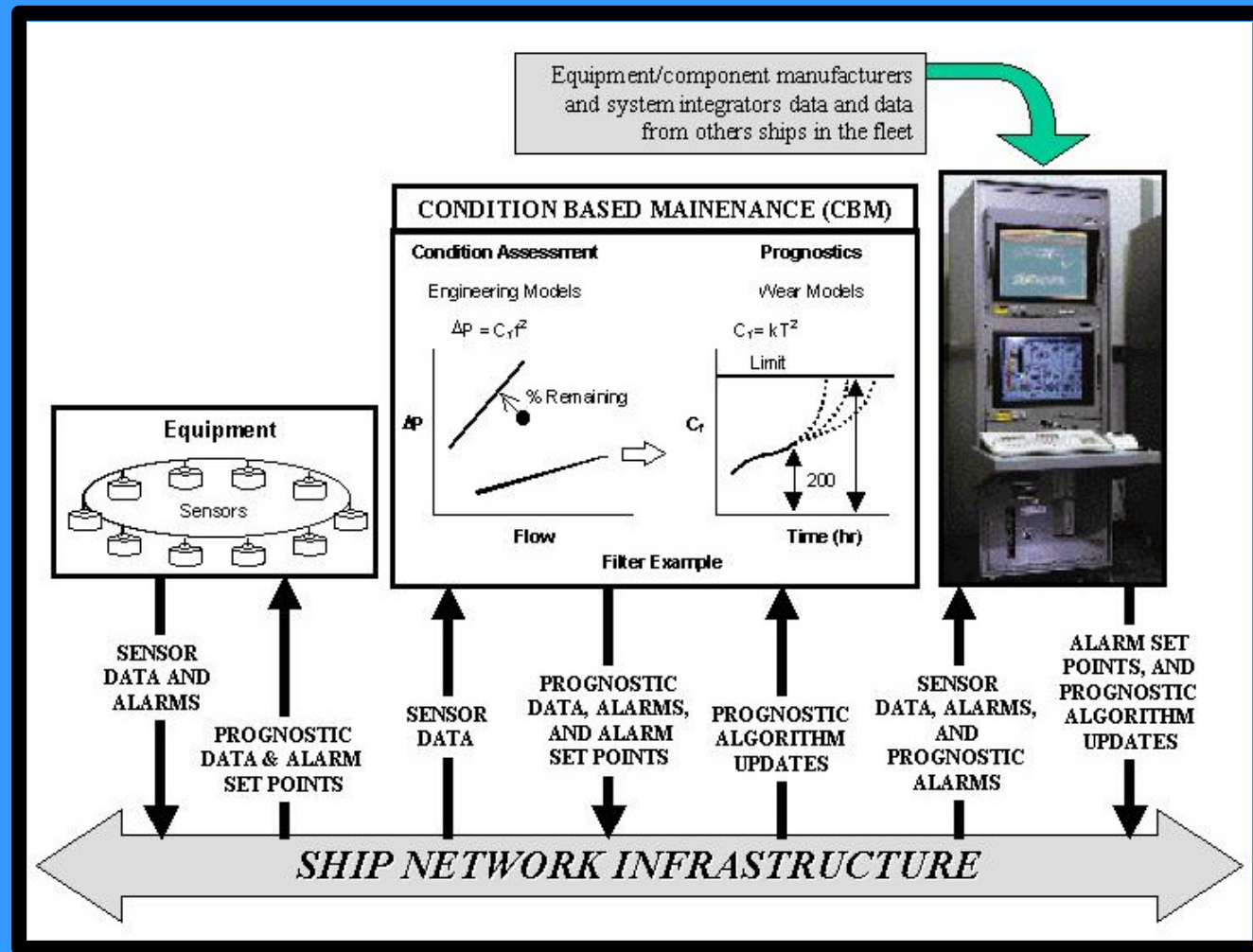
- **Condition Assessment**
  - Real Time current state of equipment
- **Prognostics**
  - Estimates the residual life of the equipment
- **Condition Based Maintenance (CBM)**
  - Uses Condition Assessment and Prognostics techniques to make health assessment on the machinery

# CBM Prognostics

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- Schedule maintenance during non-critical operating periods
- Bring back-up systems online prior to taking the failing system off-line
  - Prevents downtime during the transitional period
  - Increases overall system availability
- Increase the operating life of equipment by performing minor equipment repairs that would have led to majors failures

# CBM/Diagnostic Data Flow



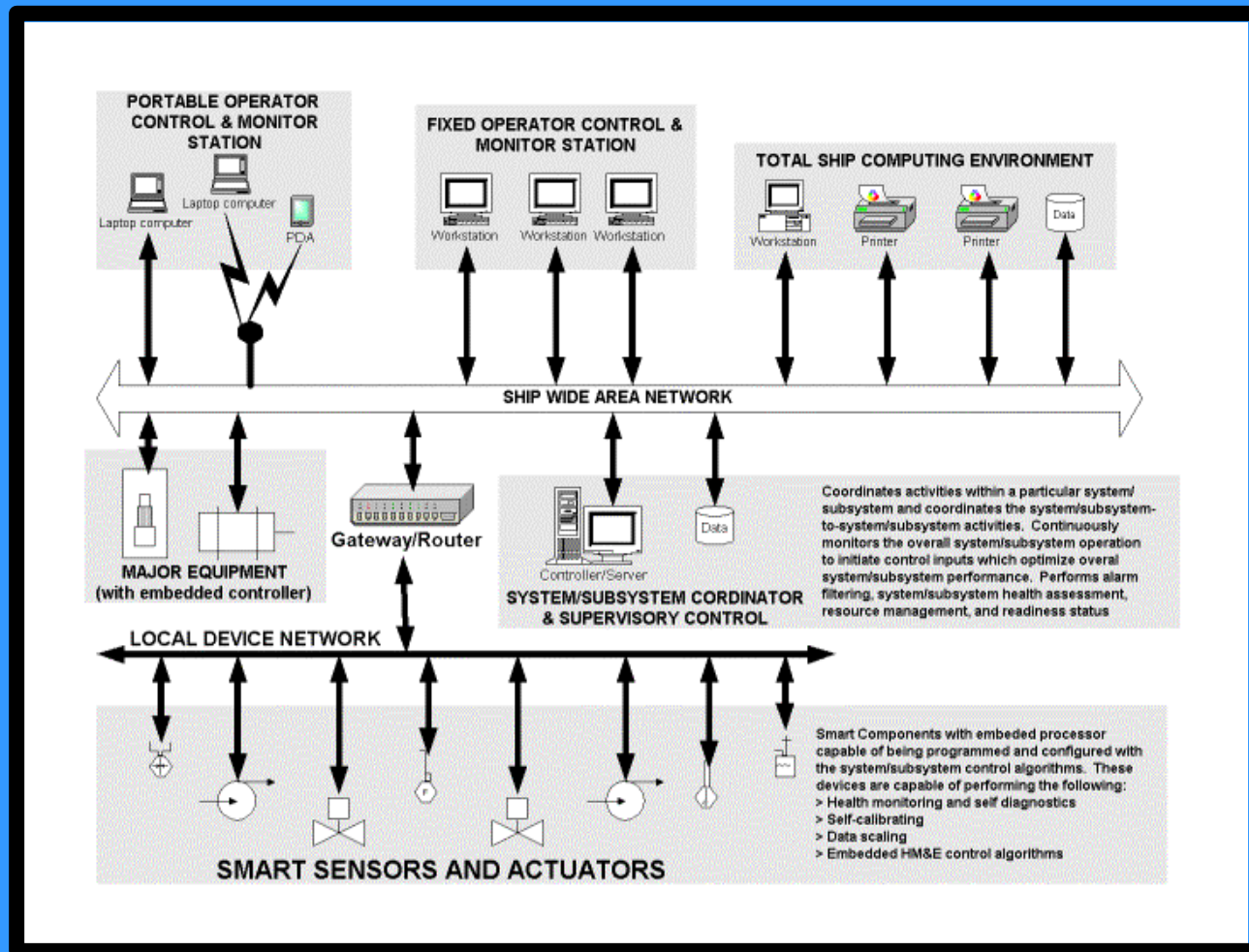
# What is CLIDCS?

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- **Component Level Intelligence**
  - Sensors appear as nodes on a network
  - Each node has a built-in processor
  - All nodes communicate peer-to-peer using standard protocol, electrical interface, and network variables
- **Distributed Control System**
  - Control system automation is distributed and performed locally at each intelligent node
  - No centralized point of control, no single point of failure
  - Human provides operational context and resolves conflicts

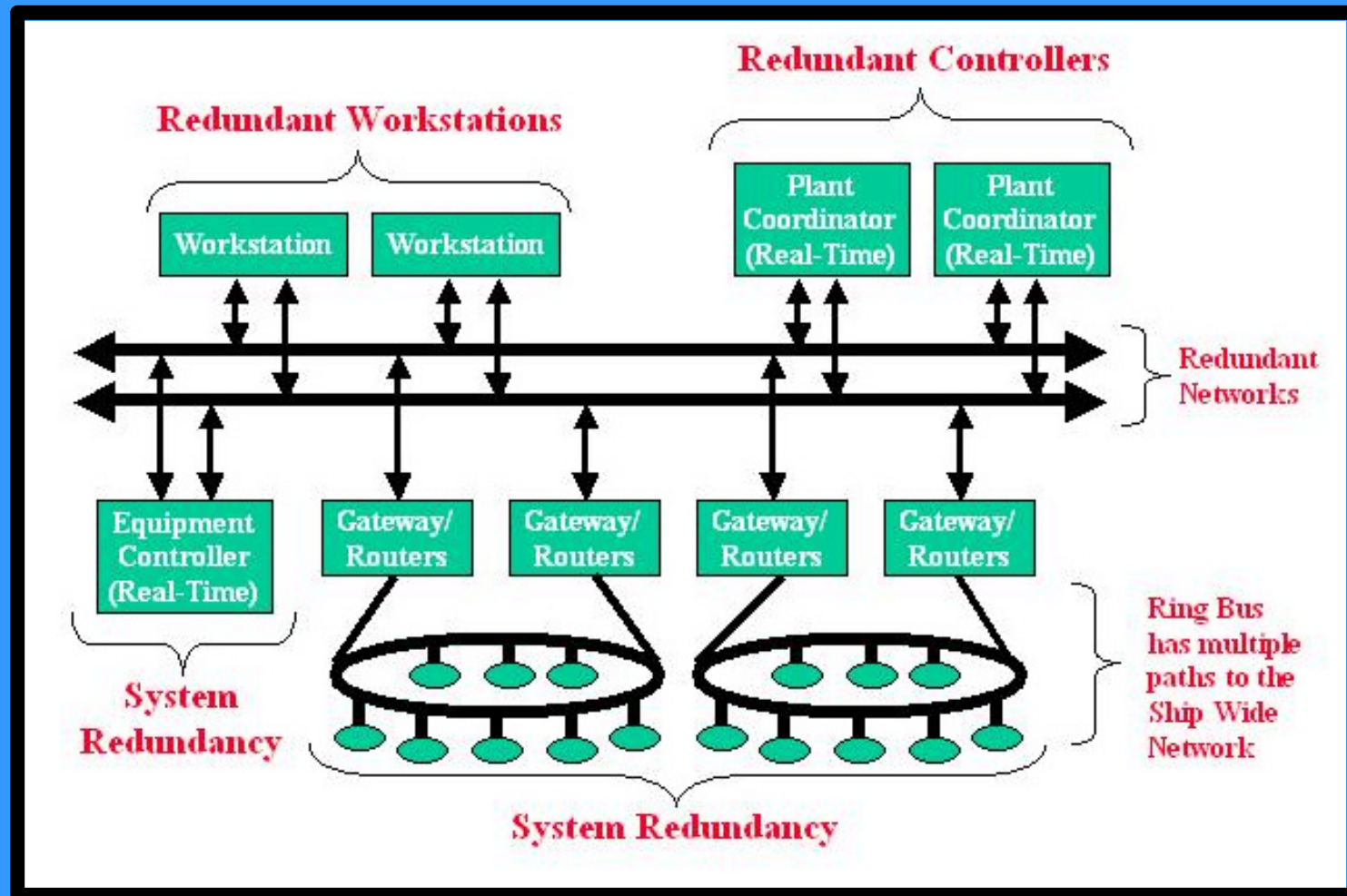
# CLIDCS Architecture





# CLIDCS Architecture

## Survivability



# Diagnostic and Control Functional Levels

## DIAGNOSTIC/CONDITION ASSESSMENT FUNCTIONS

- Plant level condition assessment monitoring
- System/subsystem readiness monitoring
- Maintenance scheduling
- Interface to equipment manufacturers and system integrators support data exchange

- Prognostic (CBM) algorithm updating
- Alarm set point updating
- Fault Report Generation
- Operator fault and trending data analysis
- System and ship wide readiness and condition assessment
- Readiness versus future mission goals assessment

- Alarm Processing and Filtering
- System/Subsystem Condition Assessment
- Subsystem Readiness assessment
- Trending and frequency response analysis and prognostic evaluation
- Fault Isolation and Replaceable Unit identification

- Alarm Generation
- Alarm set points
- Component Level equipment reconfiguration decision making
- Component Level condition assessment
- Fourier analysis (vibration data time slice)

Total Ship Computing Environment (TCSE)

Information Level

Database

Local Operator Workstation (fixed or mobile) or Real-Time Controller

Intelligent Component

HM&E

## CONTROL FUNCTIONS

- System Monitoring
- Planning
- Software Configuration Management

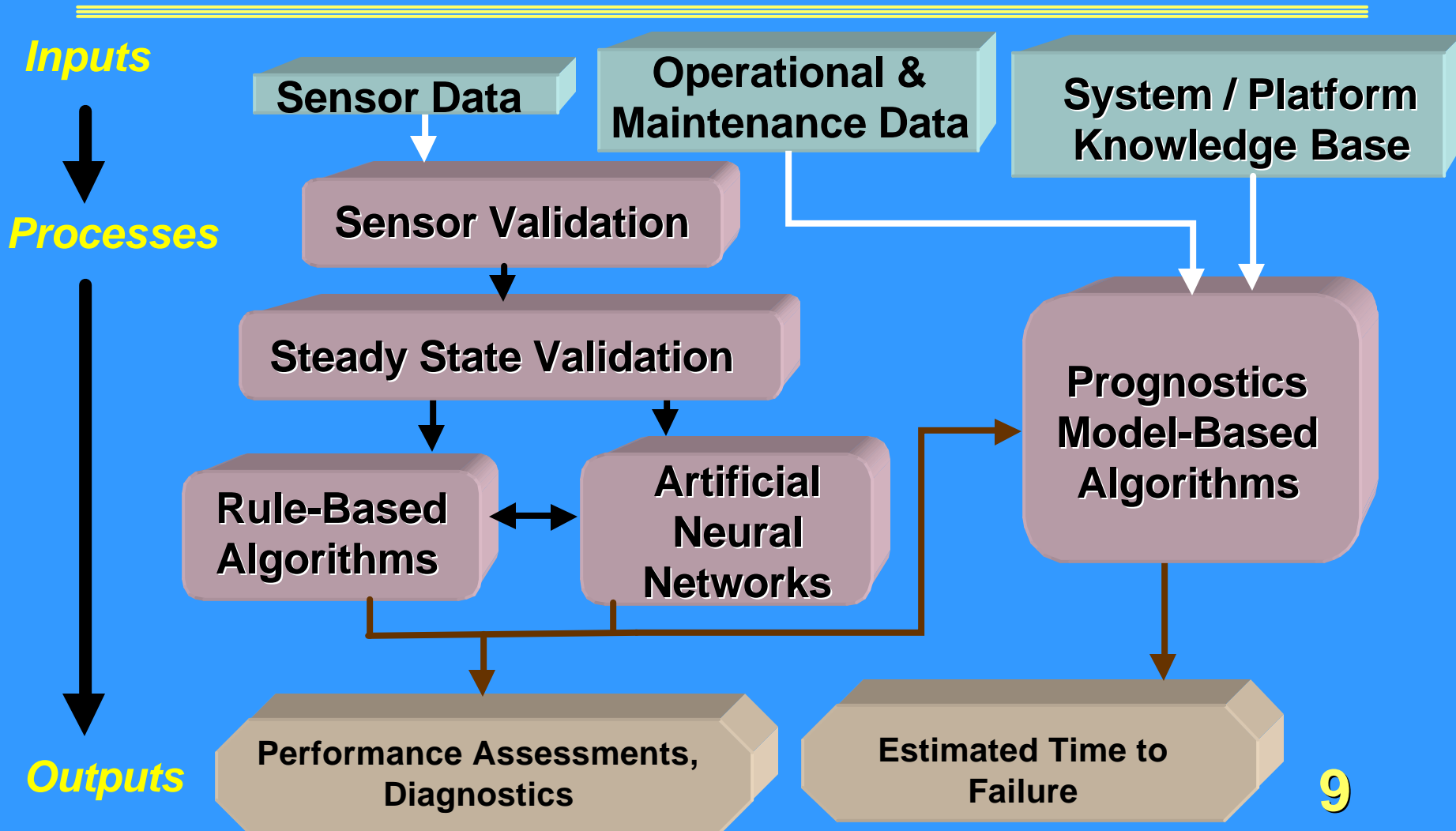
- Maintenance and Logistics Support
- Integrated Electronic Tech Manuals (IETM)
- Report Generation (Bell Log, Data Log, etc.)
- Plant Status
- Plant Modes and Context
- On-Board Training (OBT)

- Supervisory Control & Monitoring
- Plant Coordination
- Operator Command & Control Interface
- Total Plant Management & Reconfiguration
- Human In-The-Loop conflict resolution
- System optimization algorithms

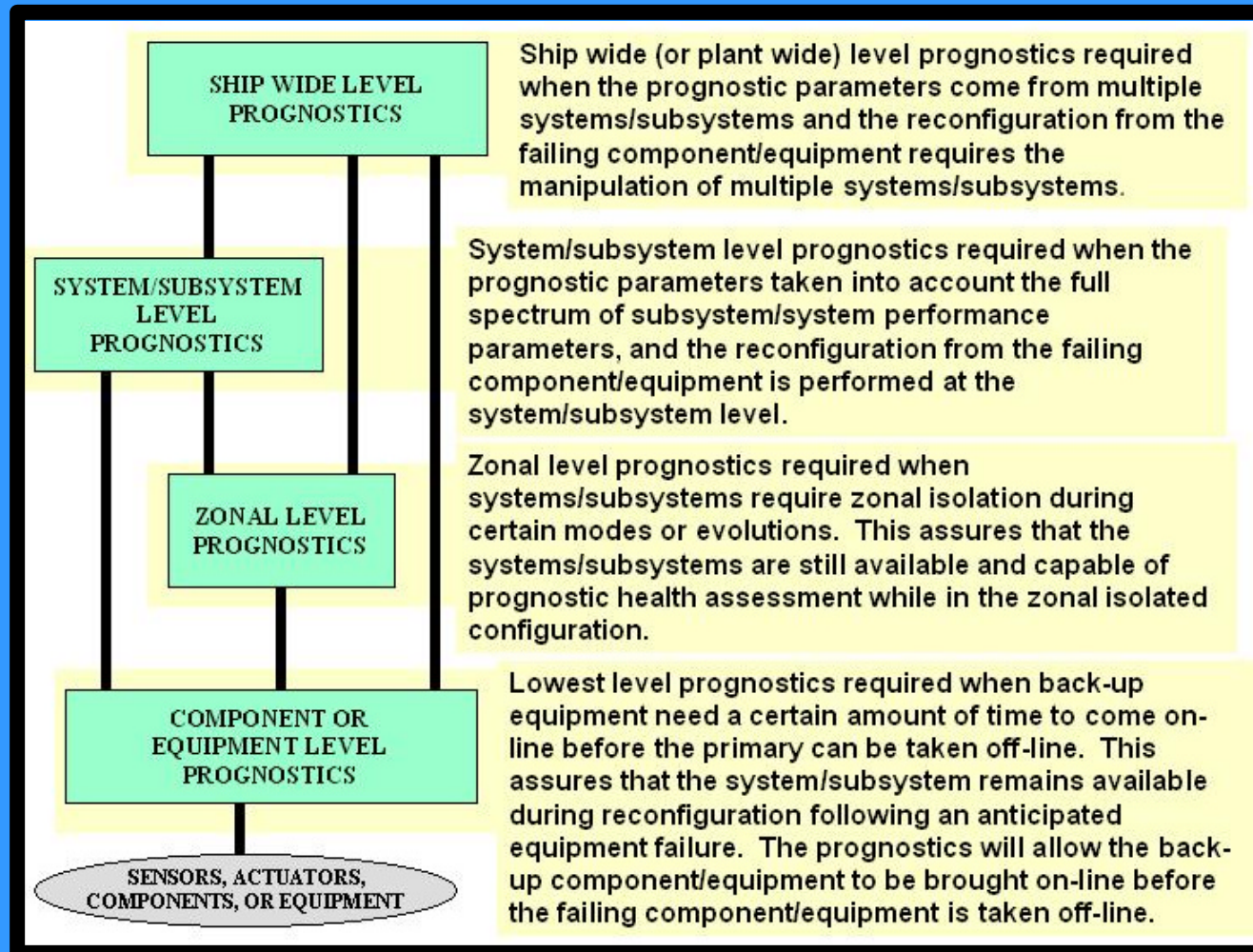
- I/O Data
- Self-Calibration
- Built-In-Test (BIT)
- Device ID
- Data Scaling
- Device Level Autonomic Control



# CBM Processing Architecture



# CBM Prognostics Functional Levels

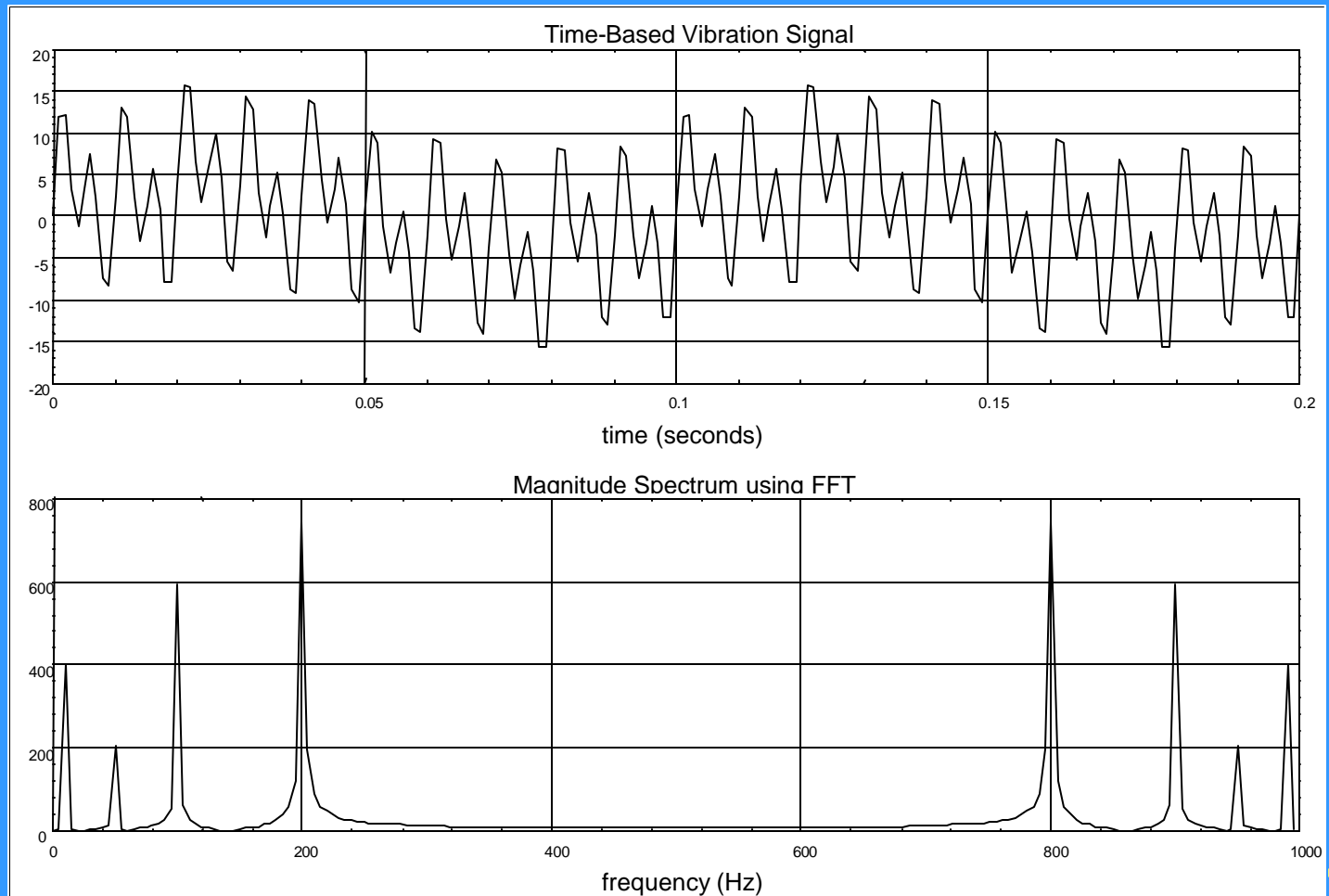


# Types of CBM Measurements

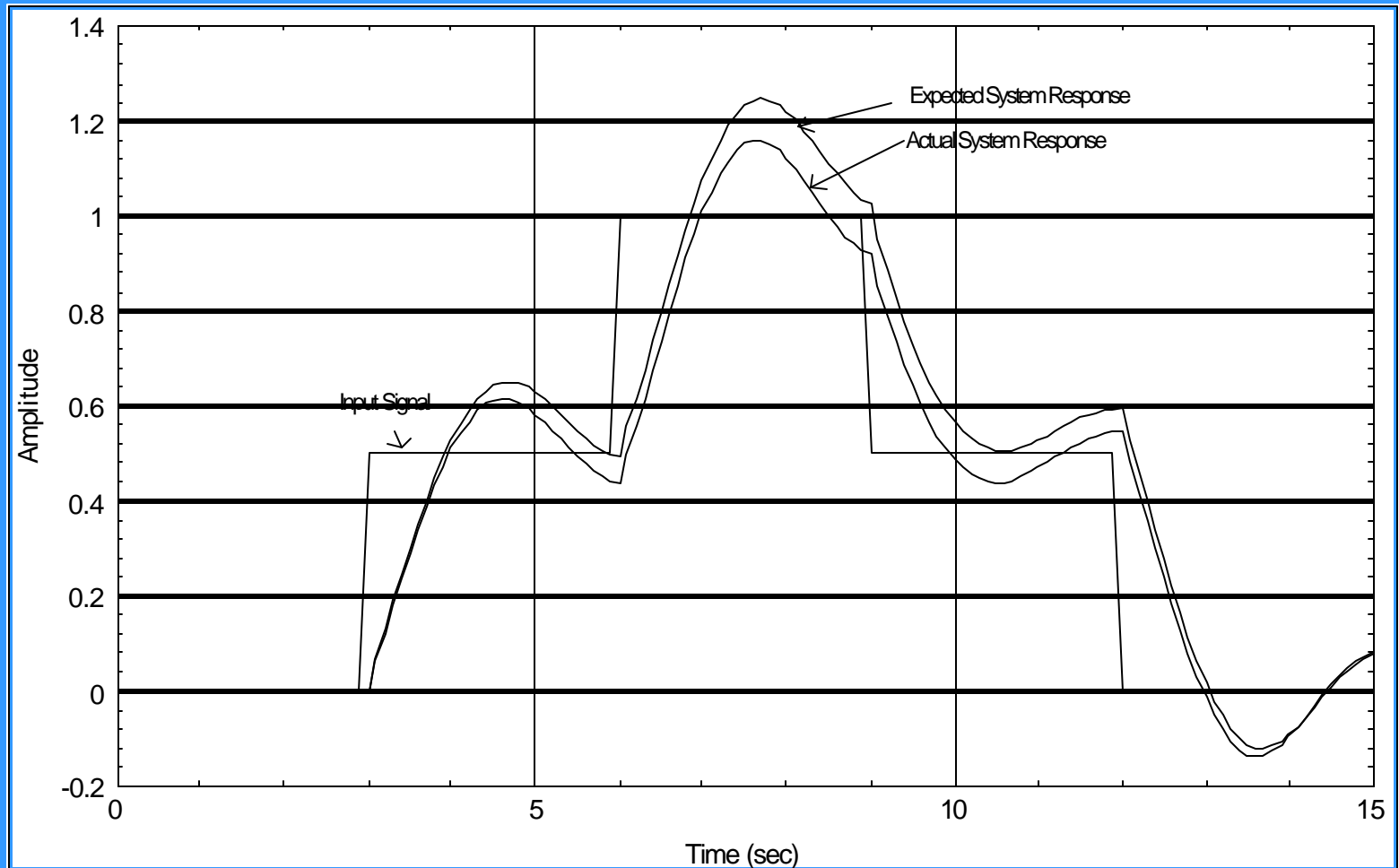
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- Vibration measurements on rotational/moving machinery
- Heat/temperature signature
- Noise/acoustic measurements
- Power/current measurements on actuators/effectors
- Signal response due to control system induced signals (periodic)

# Fourier Analysis of Vibration Data



# Condition Assessment Based On Step Response



# CBM Evaluation Techniques

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- Analyze equipment failure modes
- Statistical analysis of historical fault (and sensor) data
  - Evaluate fleet-wide database
- Evaluate data trends recorded prior to equipment failure
- Compare equipment response with model to detect undesired response characteristics



# Selection Process

